Hue University Journal of Science: Economics and Development
pISSN 2588-1205;eISSN 2615-9716
Vol. 131, No. 5B, 2022, pp. 75–86, DOI: 10.26459/hueunijed.v131i5B.6904

FACTORS AFFECTING THE ADOPTION OF KNOWLEDGE MANAGEMENT AND BUILDING INFORMATION MODELING IN CONSTRUCTION CONSULTING FIRMS

Le Tuan Vu*, Phan Nghiem Vu

Quang Tri branch, Hue University, Đien Bien Phu St., Dong Ha, Quang Tri, Vietnam

* Correspondence to Le Tuan Vu <levutuan@hueuni.edu.vn>

(*Submitted: August 14, 2022; Accepted: December 10, 2022*)

Abstract. This paper aims to identify factors affecting the adoption of knowledge management (KM) and building information modelling (BIM) in construction consulting firms. To achieve this, both qualitative and quantitative research methods are used. From the qualitative in-depth interviews with experts in the research field and experts in construction consulting firms, a final questionnaire with 30 observed variables has been developed. Next, a quantitative survey has been conducted, with the final sample including 150 participants. The research results indicate that there are five main factors affecting the adoption of knowledge management and building information modelling, including organizational readiness, organizational factors, economic factors, technological factors, and client/customer-related factors. The assessments of the importance of these factors are different according to different groups of respondents in terms of gender, age, occupation and income. organizational readiness (OR) and technology factors (TF) have the strongest effects on KM and BIM adoption intention in construction consulting firms.

Keywords: knowledge management, building information modelling, construction consulting firm

1 Introduction

The construction consulting firm is a knowledge-intensive and knowledge-generating company [1]. However, capturing the valuable knowledge from the best practices of a project and then transmit to others always deal with challenges. The multi-disciplinary, multi-organizational, and temporary nature of construction design projects causes valuable knowledge to be retained with individuals and get lost with time [2]. Therefore, it is critically important to effectively capture and share the experience-based knowledge generated in construction design projects to improve decision-making based on continuous learning. In recent years the terminology “knowledge management” has been introduced. Knowledge management (KM) seeks to formalize how companies exploit their knowledge assets by harnessing organizational knowledge, promoting greater collaboration between groups with similar interests, and capturing and using lessons learned from previous projects [3]. The success or even the survival of any organization depends on how effectively it manages the knowledge present internally and externally [3–5]. Reusing existing organizational knowledge gained via experience can significantly reduce the time spent on problem-solving and increase the quality of work. Two types of knowledge exist within organizations; implicit and explicit. The construction sector has made significant efforts to develop and implement systems to manage capturing, storing, and retrieval of clear project-related information [5]. Some examples of direct knowledge are procedure manuals, organization maps, work breakdown structures, document management systems, collaborative intranets, extranets, etc. However, not enough attention has been paid to managing tacit knowledge [2].

The current challenge to KM implementation in construction organizations is the lack of systematic procedures for developing and applying knowledge management systems (KMSs). Various KM models have been developed to support KM activities. However, the existing KM models and tools may have some problems in many circumstances, which cannot be used efficiently and effectively [6].

Building information modelling (BIM) has emerged as a solution to effective collaboration and learning processes. The current use of Building Information Modelling (BIM) is focused on digital data management and information exchanges with little consideration and exploitation of experience-based knowledge generated in projects, which is arguably more valuable for enabling improvement in the construction industry [7]. Much information is exchanged, and potential lessons learned are developed in BIM activities. However, BIM practices focus on digitalizing traditional information exchanges among project stakeholders. Hence, there is little consideration of how experience-based knowledge can be effectively captured in BIM-enabled projects and used for continuous improvement. This would lead to the loss of knowledge that will negatively impact BIM design and collaborations [8].

Therefore, an integrated approach to conducting knowledge management within the scope of BIM is needed so that the knowledge derived from the validation process of lessons learned can be stored in the knowledge management system that may be useful for later stages and future projects. This research thus is conducted to identify the factors affecting the adoption of KM and BIM in construction consulting firms and analyse the differences among groups of construction consulting firms in assessing the importance of those factors in their adoption decision.

2 Literature review

Knowledge management (KM) in construction projects is an integrated approach to create, capture, access, and use a professional’s domain knowledge of products, services, and processes [3]. During the construction phase of a project, most project-related problems, solutions, experiences, and know-how are in the minds of individual engineers and experts [9]. Implicit knowledge is not customarily documented or stored in a system database. They are capturing tacit knowledge and making it available as explicit knowledge is essential to knowledge management in the construction phase: the reuse of knowledge in other projects and the preservation of such knowledge as corporate property [10]. Experience, problem-solving, know-how, know-what, and innovation are created or performed in the construction phase of any project. Implementing knowledge management allows tacit knowledge to be reused in other projects and accelerates improving operations in the construction phase [9].

Building information modelling (BIM) is a process supported by various tools, technologies and contracts involving the generation and management of digital representations of physical and functional characteristics of places [8]. Building information models (BIMs) are computer files which can be extracted, exchanged or networked to support decision-making regarding a built asset [11].

The research topic on knowledge management (KM) and building information modelling (BIM) has received significant attention from the construction research community worldwide over the last decade. Current literature mainly focuses on five sub-topics: First, developing a framework to enable Construction consulting organizations to understand the business impact of their KM strategies [4]. Second, developing a tool to provide a structured approach to KM problem definition and strategy formulation for a Construction consulting organization [12]. Third, presenting an activity-based Knowledge Management system for capturing the knowledge generated in the construction phase [13]. Fourth, proposing knowledge maps to capture and reuse knowledge in construction projects and developing a framework (Knowledge Document Management) for a web-based portal that enables users to search and read construction documents in different formats [11]. Fifth, developing a web-based KM system which allows for “the live” capture of knowledge that can be subsequently used in the same project as well as future projects [14].

Regarding the aspect of identifying and analyzing the factors affecting the adoption of knowledge management systems (KM), and BIM processes (BIM), not much research has been done yet [15–17]. Most of the existing studies have only identified the challenges of the application, the benefits and limitations of KM, BIM in practice [15]. From the current literature, there are five prominent groups of factors below.

Organizational readiness

This factor indicates the relationship between people, processes, systems and performance measurement [19]. It requires synchronization and coordination without which no implementation will be successful. Some key aspects that reflect an organization's readiness include perception of knowledge as flow or stock; level of skill and expertise; motivation; willingness to accept solutions from others; social setting network capabilities; experience in it; organizational culture; level of trust among members [9, 17].

Organizational Factors

This factor encompasses all those elements that influenced the way that the organisation, and resources within it, behave [17]. Some key aspects that describe organizational factors include the level of competition with other organizations; commitment and awareness of the company; organizational structure and policy; management leadership and support; process problems; type of ownership [9, 16].

Economic Factors

This factor affects and influences an organisation's financial status [15]. Some key aspects that describe economic factors include the high cost of software procurement; high cost of hardware; investment for internet speed and big data for sharing and storing knowledge; cost of training and operations; the financial ability of the organization [10, 4].

Technological Factors

This factor refers to the production methods, use of equipment and quality of the product [17]. It includes force related to scientific innovations and improvements in products as well as production technology [9]. Some key aspects that describe technological factors include hardware specifications for KM & BIM; continuous change and advances in the industry; availability and specification of information and communication technology (ICT) for KM and BIM; its infrastructure and support systems; method and tools available for KM [15, 20].

Client/Customer-Related Factors

This factor affects client/ customer satisfaction and can be categorized as client/ customer perceived quality, value, and service. By harnessing these factors, the firms can provide positive, consistent client/ customer experiences and create true client/ customer loyalty [15]. Leadership capacities of the client to encourage sharing tacit knowledge; Decreased time and cost of the project; Improved customer relationship management; Improved quality of products; Improved supply chain management [18, 6].

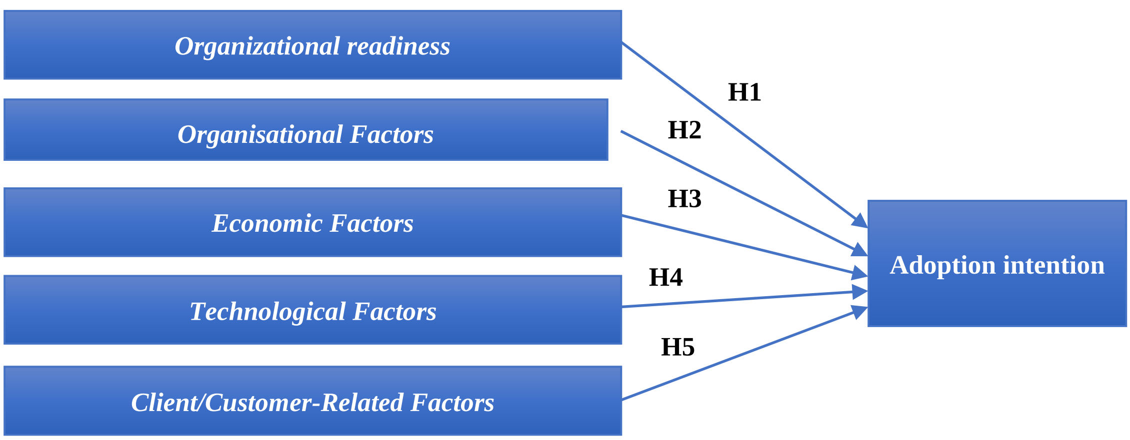

Figure 1. Proposed research model

Proposed research model

In this study, by referencing the proposed framework of Lin [17], Tsai and Hung [15], Maguire et al. [9], and other studies (Table 1), the author has proposed a model to assess factors affecting the adoption of KM and BIM in construction consulting firms. Considering that it was not possible to include all potential factors affecting KM and BIM adoption, the choice of theoretical constructs in the current study was determined through an extensive literature review as well as informal conversations with various executives in construction companies.

First, for the organizational aspect, **organizational readiness and organizational factors** are especially important for innovation adoption to facilitate core businesses, because the organization needs to be in a condition favorable for the innovation to function effectively. This study chose organizational readiness that was used in previous innovation adoption studies [15], as this study aimed to test its applicability in different types of KM and BIM adoption.

Hypothesis 1. Organisational readiness positively affects adoption intention.

Hypothesis 2. Organisational factors positively affect adoption intention.

Second, this study attempts to examine **economic factors** as the determinant of KM and BIM adoption as these factors appear often in our informal conversations with KM practitioners.

Hypothesis 3. Economic factors positively affect adoption intention.

Third, unlike data and information, knowledge is processed in the minds of individuals. KM and BIM involve integrating tacit (stored in mind) with explicit (stored in a database) knowledge [17]. This study included **technological factors, client/customer-related factors** in the research model. Such a construct is not commonly investigated in KM and BIM adoption studies, so it is included here, given the current emphasis on organizational learning culture [18].

Hypothesis 4. Technological factors positively affect adoption intention.

Hypothesis 5. Client/Customer related factors positively affect adoption intention.

In general, a new conceptual framework is built based on the adoption of knowledge management theories. In this framework, there are five hypotheses are proposed. Organisational readiness (skill, expertise, competence, trust, acceptance willingness), organisational factors (competition, commitment, structure, leader supports), economic factors (financial ability, cost management), technological factors (IT infrastructure, IT experience), and client/customer-related factors (perceived benefits) provide essential foundations for the adoption of knowledge management systems and building information modelling in construction consulting firms. If the firms invest in these aspects, the acceptance rate would be increased significantly [5, 6, 15].

3 Methodology

In this study, both qualitative and quantitative methods are leveraged to achieve the research objectives. In the first step, the qualitative method is used to calibrate the preliminary scale (the scale proposed by the author) and build an adjustment scale to evaluate the factors affecting the adoption of KM and BIM in construction consulting firms. Specifically, the study conducted group interviews and individual interviews with eight experts who are company managers and employees directly involved in the design and construction process (these are people who are knowledgeable about the practice of knowledge management activities in the study area). These experts reviewed the questionnaire and were asked to comment on reliability, comprehensiveness, and accuracy. After that, the official scale was formed based on the investigation of the adjusted scale for a sample of 30 designers working in different companies with high representation in the field. This helps to revise the original questionnaire.

In the second step, the quantitative questionnaires are used in the form of a 5-point Likert scale, running from 1 (extremely unimportant) to 5 (extremely important). The final questionnaire is designed with 30 questions on factors affecting the adoption of knowledge management and BIM in construction consulting firms. The survey was distributed by e-mail to construction design managers and experts in Central of VietNam. 176 questionnaires were distributed from September 2019 to June 2021, and 150 valid responses were retrieved. The sample size is judged based on the function of estimating the population means and guaranteed effect size of analysis results. Most respondents were college graduates, between 31-55 years old, with 5-30 years of working experience, holding design certification with class 2 or higher issued by the Vietnamese government, and having experience with BIM. Due to the relevant informants being hard to locate and access. All participants in this study are recruited by referrals and snowball sampling techniques. This technique also helps to reduce the hesitance of participants. After collecting and cleaning, qualitative data and quantitative one are analyzed using Nvivo 12, SPSS 20, and Excel software.

4 Results of research

4.1 Sample Descriptive Statistics

The final sample in this study includes 150 respondents who are engaged in the field of construction design at construction consulting firms. The majority of respondents are male (58.7%), aged between 18 and 50 (76%), and have the most common income of 10 to 15 million (32.3%). Construction-related designers at State-owned firms (28.3%) and at private firms (30.5%) are the two most popular occupations (Table 2).

Table 2. Sample descriptive statistics

Classifications	Frequency (n = 150)	Ratio (%)	Classifications	Frequency (n = 150)	Ratio (%)
Sex			**Ages**		
Male	88	58.7	Under 18 years old	27	18.0
Female	62	41.3	18 to 32 years old	63	42.0
Occupations			33 to 50 years old	51	34.0
Students	25	6.5	Over 50 years old	9	6.0
Construction-related designer at State-owned firms	35	28.3	**Average monthly income**		
Construction workers	25	6.7	Under five million	26	17.3
Construction instructor	19	15.7	5 to 10 million	48	31.0
Building contractors	11	6.3	10 to 15 million	47	32.3
Construction-related designer at private firms	29	30.5	15 to 20 million	17	11.3
Others	6	6.0	Over 20 million	12	8.0

Source: SPSS analysis results, 2021

4.2 The results of exploratory factor analysis (EFA) and scale reliability testing

Factor analysis explored and detected the underlying relationships among observed variables. This statistical technique identifies a relatively small number of factors that can be used to represent relationships among sets of multiple interrelated variables [21]. In this study, 30 variables were subjected to factor analysis using principal component analysis and varimax rotation. The principal components factor analysis method with Varimax rotation was used to determine the number of extracted factors in each scale [22].

The EFA results indicate that the Kaiser-Meyer-Olkin coefficient has a value of 0.699 (>0.5) with the significance level of the test. Bartlett's Test of Sphericity is 0.000 (<0.05). There are 30 variables grouped into five factors. Considering the Eigenvalue of the factors, all factors have an Eigenvalue greater than 1 retained in the analytical model. Total variance extracted 65.767% (>50%) [18] (Table 3).

The reliability of the scale is then checked using the Cronbach Alpha coefficient. This index measures the consistency of observed variables within the same scale. In this study, the values of all five tested scales are more significant than the recommended value of 0.7 [23]. The scales, therefore, fulfil the requirements and can be used for further analyses (Table 3).

Table 3. EFA analysis results and Cronbach's Alpha coefficients

Variable groups	Number of variables	Initial Eigenvalues	% of Variance	Cronbach's Alpha
Organizational readiness	8	8.425	26.328	0.931
Organizational factors	7	4.092	12.788	0.918
Economic factors	5	3.301	10.314	0.875
Technological factors	5	2.244	7.012	0.846
Client/Customer related factors	5	2.984	9.325	0.859
Total Extracted Variance: 65.767%				

Source: SPSS analysis results, 2021

4.3 Analyze the difference

One-way ANOVA test (with qualitative variables – age, occupation, and income) and independent sample t-test (with gender variable) with 95% confidence is used to test the differences in the assessment of different groups of participants working in the construction-related field. The hypothesis H0 of the Levene test is that all groups of samples have the same variance. Sig test results. Are greater than 0.05, showing that all groups of test variables meet this condition [1].

The results of the differential analysis shown in table 4 indicate that there are in different customer groups by gender when the importance of organizational readiness (H1) and technology factors (H4), p-value are 0.000 and 0.042 respectively. Classified by age, there were differences in the assessment of Organizational readiness (H1), Organizational factors (H2) and Economic factors (H3) groups, with p-values being 0.005, 0.008 and 0.009 respectively. Classified by occupation, there is the only difference in the assessment of the factor Organizational readiness (H1), p-value is 0.011. Finally, classified by income, there is a difference in the assessment of Organizational readiness (H1) and Organizational factors (H2), with p-value are 0.000.

Table 4. Difference test results

Evaluation criteria group	Demographic characteristics			
	Sex	Age	Occupation	Income
Client/ Customer-related factors (H5)	0.419	0.260	0.324	0.132
Organizational readiness (H1)	0.000**	0.005*	0.011*	0.000*
Organizational factors (H2)	0.118	0.008**	0.061	0.000*
Economic factors (H3)	0.369	0.009*	0.082	0.143
Technology factors (H4)	0.042**	0.416	0.022*	0.174

* One-way ANOVA test has statistical significance (less than 0.05)

** Independent sample t-test is of statistical importance (less than 0.05)

Source: SPSS analysis results, 2021

4.4 Linear regression analysis

After testing the model fit (with the adjusted R^2 value = 0.606 > 0.5 and Sig. of the F test = 0.000 < 0.05), as well as the tests on the defects of the model (with the Durbin-Watson value = 1,832 in the range (1.6; 2.6) and the VIF values are all less than 10). This proves that the theoretical model also meets the requirements to ensure meaningfulness [23].

Regarding testing the relationship between statistical hypotheses, all 5 hypotheses H1, H2, H3, H4, H5, H6 corresponding to 5 test relationships are accepted with the corresponding regression coefficients, respectively 0.405; 0.125; 0.277; 0.393; 0.156 and are clearly shown in Figure 2.

The general regression equation of the model is rewritten as follows:

$$AI = 0.405*OR + 0.125*OF + 0.277*EF + 0.393*TF + 0.156*CF$$

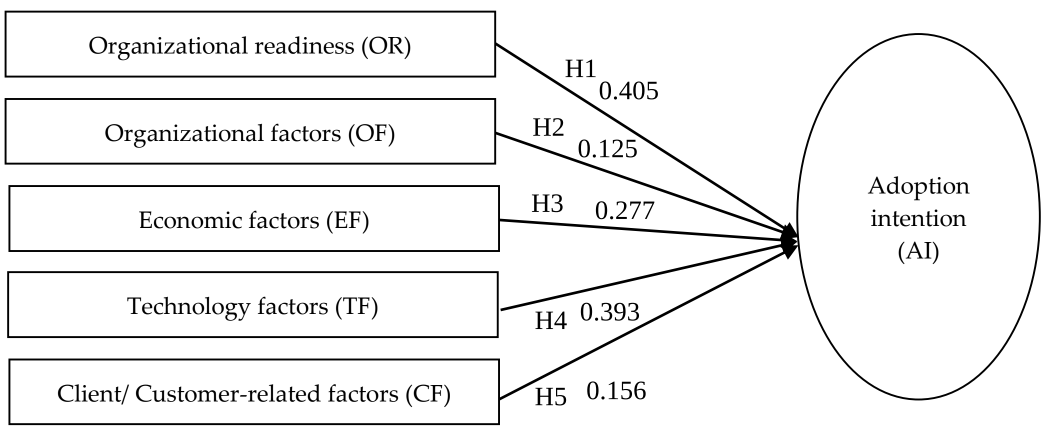

Figure 2. Results of linear regression analysis

5 Conclusion

Knowledge management (KM) and building information modelling (BIM) are now becoming vital applications in any construction organization's business strategies and complement organizational business activities. Lessons learned from the construction industry have proved that reusing and sharing knowledge can enhance construction projects successfully by decreasing cost and time of completion and improving the whole competition of the organization. However, current BIM practices give little consideration to capturing and exploiting the experiential knowledge generated in BIM-enabled projects, thus delivering suboptimal value. The identification of influencing factors has been considered necessary, especially in the application of new ICT technology [8].

Current literature on the factors affecting the adoption of KM and BIM in construction consulting firms has not yet been developed and finalized. In this paper, through reference to existing studies, combined with qualitative interviews with experts, the proposed research model is built with 5 main groups of factors, including organizational readiness, organizational factors, economic factors, technological factors and client/Customer related factors.

Research results have also shown differences in the assessment of the importance of the above factors. Specifically, the difference was most expressed between different groups of respondents in terms of age, gender, occupation income when assessing the importance of organizational readiness, organizational factors, economic factors, and technological factors. In contrast, there is almost no difference when assessing the group of customer/Customer related factors. These results are entirely compatible with the cultural characteristics of construction consulting firms in the Central region of Vietnam. Finally, the regression analysis indicates that organizational readiness (OR) and technology factors (TF) have the strongest effects on KM and BIM adoption intention in construction consulting firms.

Regarding the research contribution, the results from this study supplement the current understanding of the adoption of knowledge management. Through the case of construction companies, the studies suggest new aspects to current literation on knowledge management. A new conceptual framework from this study also provides important guidelines for practitioners, and managers to implement and adopt knowledge management to their firm in reality.

In general, this paper identifies the factors influencing the adoption of BIM and KM to enable continuous improvement in decision-making in construction projects. Another significant contribution of this paper is to identify and emphasize the economic factor (factors related to the investment capacity of consulting firms to integrate BIM and KM) as an essential factor to be considered while integrating experiential knowledge into BIM practice.

References

1. A. Elfar, A. M. Elsaid, and E. Elsaid (2017), How knowledge management implementation affects the performance of Egyptian construction companies, *Journal of Applied Business Research (JABR)*, 33(3), 409–438.
2. B. Dave and L. Koskela (2009), Collaborative knowledge management—A construction case study, *Automation in construction*, 18(7), 894–902.
3. P. Carrillo and P. Chinowsky (2006), Exploiting knowledge management: The engineering and construction perspective, *Journal of Management in Engineering*, 22(1), 2.
4. P. Carrillo (2003), IMPaKT: A framework for linking knowledge management to business performance, *Electronic Journal of Knowledge Management*, 1(1), 1–12.
5. P. Carrillo, H. Robinson, A. Al-Ghassani, and C. Anumba (2004), Knowledge management in UK construction: Strategies, resources and barriers, *Project management Journal*, 35(1), 46–56.
6. K. Y. Wong (2005), Critical success factors for implementing knowledge management in small and medium enterprises, *Industrial management & Data systems*, 105(3), 261–279.
7. Nguyen The Quan, Luu Phuong Quynh, Application of BIM in design conflict detection: A case study of Vietnam, *IOP Conference Series: Materials Science and Engineering*, 869(2), 022038.
8. S. Liu, B. Xie, L. Tivendal, and C. Liu (2015), Critical barriers to BIM implementation in the AEC industry, *International Journal of Marketing Studies*, 7(6), 162.
9. S. Maguire, S. C. L. Koh, and A. Magrys (2007), The adoption of e-business and knowledge management in SMEs, *Benchmarking: An International Journal*, 14(1), 37–58.
10. C. O. Egbu (2004), Managing knowledge and intellectual capital for improved organizational innovations in the construction industry: An examination of critical success factors, *Engineering, Construction and Architectural Management*, 11(5), 301–315.
11. Y.-C. Lin, L.-C. Wang, H. P. Tserng, and S.-H. Jan (2005), Enhancing knowledge and experience exchange through construction map-based knowledge management system, in *Construction Research Congress 2005: Broadening Perspectives*, 1–10.
12. F. Bonert (2019), Facilitating the Digital Transformation of Building Design and Engineering Companies by Transferring Knowledge across Projects, Master's Thesis, Utrecht University.
13. H. P. Tserng and Y.-C. Lin (2004), Developing an activity-based knowledge management system for contractors, *Automation in construction*, 13(6), 781–802.
14. H. C. Tan, P. M. Carrillo, C. J. Anumba, N. Bouchlaghem, J. M. Kamara, and C. E. Udeaja (2007), Development of a methodology for live capture and reuse of project knowledge in construction, *Journal of management in engineering*, 23(1), 18–26.

15. J. C.-A. Tsai and S.-Y. Hung (2016), Determinants of knowledge management system adoption in health care, *Journal of Organizational Computing and Electronic Commerce*, 26(3), 244–266.
16. M. Saini, M. Arif, and D. J. Kulonda (2017), Critical factors for transferring and sharing tacit knowledge within lean and agile construction processes, *Construction Innovation*, 18(1), 64–89.
17. H.-F. Lin (2013), Examining the factors influencing knowledge management system adoption and continuance intention, *Knowledge Management Research & Practice*, 11(4), 389–404.
18. B. Trigunarsyah, Organizational culture influence on client involvement, *Engineering, Construction and Architectural Management*, 24(6), 1155–1169.
19. M. Arif, A.-Z. Mohammed, and A. D. Gupta (2015), Understanding knowledge sharing in the Jordanian construction industry, *Construction Innovation*, 15(3), 333–354.
20. H. S. Robinson, P. M. Carrillo, C. J. Anumba, and A. M. Al-Ghassani (2001), Perceptions and barriers in implementing knowledge management strategies in large construction organisations, in *Proceedings of the RICS COBRA Conference*, 451–460.
21. M. Norusis (2005), Spss 14.0 Statistical Procedures Companion Prentice-Hall, *Inc. Upper*.
22. D. E. Johnson (1998), *Applied multivariate methods for data analysts*. Duxbury Resource Center.
23. J. F. Hair (2009), Multivariate data analysis.